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ROLE MODEL EFFECT IN A HARSH ENVIRONMENT: SCIENCE OLYMPIADS IN THE NORTHEAST BRAZIL

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Role Model Effect in a Harsh Environment: Science Olympiads in Northeast Brazil

Abstract

The present work aims to understand the impact of an award at OBMEP (Brazilian Mathematics Olympiad of Public Schools), on school math scores in a harsh environment. For this purpose, it is used the Panel Model with Fixed Effects, applied to public schools in Ceará, State in the Brazilian Northeast. In total, 1,882 public schools were followed between 2009 and 2017, observing specifically K9 students. While the previous literature demonstrates the impact of schools participating in OBMEP and how awards have an impact on the award winners, this study demonstrates how the effects spillover towards their peers. In short, all awards have positive and statistically relevant impacts, but a *gold* medal is, on average, 3.2 times more impactful than the others.

Keywords: Role Model; Science Olympiads; Education; OBMEP; Brazil; Panel; Fixed Effects.

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Role Model Effect in a Harsh Environment: Science Olympiads in Northeast Brazil

1. Introduction

Considering various indicators from different segments, the problem of Brazilian education seems to be institutional. OECD[1], Organization for Economic Cooperation and Development, indicates in its reports that Brazil is a country with considerable investments in Education. 2016's data show that Brazil is the 6th country which most invests public funds on institutions from Primary to Higher Education, concerning the GDP, the equivalent of 5.1%, and the 3rd country which most invests public funds on institutions from Primary to Higher Education, concerning the total public expenditure, about 14%.

Nevertheless, considering enrollment and graduation, the situation is one of the most complicated. 2017's data show that Brazil is the 4th worst country regarding enrollment of students between 15 and 19 years old, with about 66.9%[2], and by the end of 2017, approximately 22% of Brazilian teenagers between 15 and 17 would not finish a school year because of either withdrawal or dropout.[3]

Finally, when it comes to results and learning, Brazil demonstrates a terrible performance. According to 2015 PISA's data, in a rank of 69 countries, Brazil was the 62nd regarding Science performance of 15-year-old students, the 64th regarding Mathematics performance of 15-year-old students, and the 60th in economic, social and cultural status.[4]

On the other hand, good results have been observed in some Brazilian areas, as a consequence of various specific programs. One of these examples would be programs based on the creation of a competitive academic environment among students. Awarding based on performance or merit might be doubly effective for the improvement of educational indicators. The first and most frequent factor according to the literature is the recognition of the awarded students. However, such recognition also influences students outside this select group, which may be explained by the creation of role models, causing, for instance, peer effect.

Ebenstein, Lavy and Roth (2017) discuss the benefits of recognition policies for awarding students. Kremer et al. (2009) present a pre-evaluation approach for future awarded students due to the effort dedicated to the competition rather than the award itself. Both demonstrate positive results for recognition policies. Moreira (2017) studies this for the Brazilian case and reinforces this result, showing that such effects spillover towards peers, with even stronger effects on students whose levels are closer to those of the awarded ones.

First of all, it is important to mention the previous literature on peer effects related to recognition, which provided the basis for these practices in education. Chung (2000) and Ray (2006) are the latest examples regarding the evolution of the literature on this issue, demonstrating that there are recognition spillovers towards their peers, either positive or negative, in different areas.

Regarding education, discussions take two directions. The first one deals with the effects of those public policies on schooling behavior, as duly presented by Sacerdote (2001), Austen-Smith and Fryer (2005), and Fryerand Torelli (2010), culminating in similar positive effects on academic performance. Moreira (2017), however, takes another direction, little-discussed nowadays, analyzing the effect of the awarded students on their peers in the public school environment. She takes into consideration two similar results in different contexts: Bursztyn and Jensen (2015), and Sequeira, Spinnewijn and Xu (2016).

Sequeira et al. (2016) studies the case of India and demonstrates that, in this context, the effects of the recognition are restricted to the awarded student, without spillover. On the other hand, Moreira (2017) shows positive results from both groups and studies a similar case to the one to be suggested in this work, investigating the impact of the honorable awards in the OBMEP (Brazilian Mathematics Olympiad of Public Schools), on Brazil level. The present work also considers the Brazilian public education but only addresses the second effect, the spillovers, not focusing on the results of the awarded students.

Following the recognition and spillover approach for peers, the result found by Biondi at al (2012) brings a great contribution to public schools in Latin America. It is demonstrated that the presence of academic competition has an impact on school performance as a whole, regardless of results, causing improvement in the marks of Mathematics national evaluations, school dropout rate decline, and approval rate increase. Moreover, the Mathematics performance increases as schools take part in more editions of the competition, also OBMEP, and the cost-benefit analysis indicates positive return regarding salaries for the students of these schools, according to the result found by Binelli and Menezes-Filho (2008).

Besides reinforcing the results brought by the previous literature, demonstrating positive effects of science Olympiads for schools with awarded students in the context of public education, and not only on awarded students. In addition, this study discusses this impact in adverse environments. For this, it focuses on Ceará, a poor state located in the Brazilian northeast, which presents low per capita income, high social inequality level, and high rate of people in extreme poverty, comparing to the other Brazilian States. On the other hand, Ceará demonstrates great results of educational indicators, including 82 of 100 of the best Brazilian public schools. Besides, it also stands out for the result in the Science Olympiads, such as OBMEP.

Ceará is a curious case in Brazil. It is a poor State of Brazilian Northeast, which presents

OBMEP (Brazilian Mathematics Olympiad of Public Schools) is the most important Olympiad in Brazil, which happens in a high regularity pattern concerning the participants and awarded number. Since its beginning, in 2005, OBMEP has grown considerably when it comes to participant schools, and the percentage of Brazilian cities with participant students, more than 99% in Brazil. Moreover, the quantity of participant students is about 18 million annually, the equivalent of the population in Portugal and Switzerland combined. In 2019, more than 55 thousand students were awarded, from K6 to K12, of which about 7500 were medalists. There is no similar precedent for engagement in the Olympics in the world.[5]

Section 1 presents the motivation for this study and the literature which allows this discussion, culminating in two essential works for the context of competitions in Brazilian public education, Bionde et al (2012) and Moreira (2017). Section 2 a descriptive analysis of Ceará context in Brazilian education, in both public and private sectors, and OBMEP (Brazilian Mathematics Olympiad of Public Schools), the main national competition in Brazil. Section 3 the source of the data studied and their characteristics and limitations. Section 4 the econometric methodology, provided through a fixed effect panel, its hypothesis, and limitations. Section 5 the results found in this work. Section 6 there are the conclusions.

2. Institutional Context

Similar to other sectors, the education in Brazil punctually presents strong results internationally, being an example of policy and performance innovation, but demonstrates weak average results, signaling the great inequality present in the country.

Regarding education data, Brazil has done well since 2005, applying national standard evaluations with robust measuring statistics, such as IRT (Item Response Theory). Two great examples should be mentioned: SAEB (National Basic Education Assessment System), for students of K5 and K9, applied in all public schools in Brazil with more than 20 students, and ENEM (National High School Exam), the evaluation that is used to access all public universities in Brazil and also the majority of private institutions, even with partial places. Furthermore, it is worth mentioning the School Census, which is developed annually and collects information from students, parents, teachers, and employees of Brazilian schools.

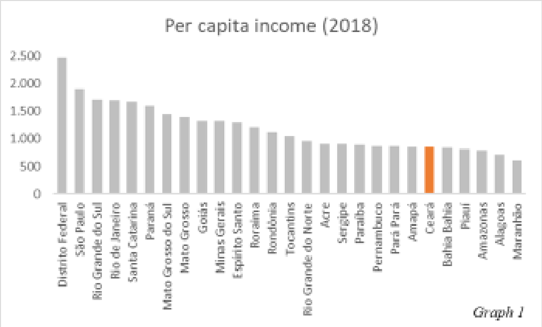
Moreover, the performance indicator of Brazilian schools, also including K5 and K9, aligns with the result of international evaluations. Thus, 6 points taken in the national indicator, IDEB (Basic Education Development Index), corresponds to the OECD average in PISA (Programme for International Student Assessment). This is an important number to demonstrate the case of Sobral, the city with the best public education in Brazil, which presents IDEB 9.1 in K5 and 7.2 in K9 in 2017, above the average of the OECD countries.[6]

In a short description, the Brazilian public system is divided between public powers according to age group. In general, cities are responsible for Kindergarten to K9, States are responsible for Secondary Education, and the federal government is responsible for public universities, the Higher Education. Nevertheless, due to Brazil's extension, there are exceptions to this pattern. Considering Basic Education, some important examples should be mentioned, such as the technical schools, dedicated to Secondary Education, which are also the responsibility of States but receive special funds for integrating professional education. Furthermore, there are the military schools, which receive funds from the federal government, and include from K6 to K12. In both cases, technical and military schools, there is a pre-selection of students according to their performance, which creates an environment of high quality. Moreover, due to the special funding of these schools and higher autonomy, their management may act more efficiently and achieve better performance indicators, approvals, higher education attendance, etc.

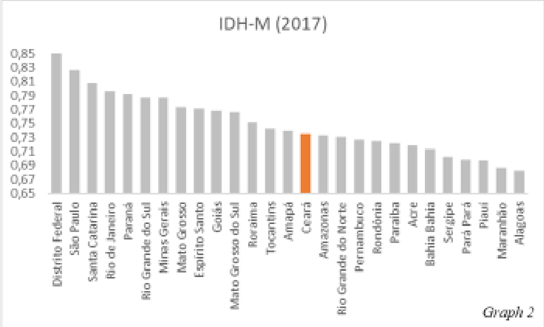
Considering the private sector, Brazil presents the particularity of private education platforms, companies that work replicating their pedagogic methodologies and standardization of content, calendar, and evaluations to various schools in different regions. The private education market in Brazil has grown strongly and sustainably, receiving high investments, besides showing good results, following the opposite direction of the Brazilian economy.[7]

In this context, Brazilian private schools, along with some military schools, compete for the best positions in national entrance exams for higher education and show good results at the international level. These schools are located in four specific cities: Fortaleza, capital of Ceará, São Paulo, São José dos Campos, and Rio de Janeiro. Schools such as Ari de Sá, Farias Brito, Anglo, Objetivo, Militar School of Fortaleza, among others, have constantly sent students to represent Brazil in international Olympiads, getting medals, competing on the same level with China, India and the United States, as well as approving students to high ranked American schools, such as Harvard, Stanford, and MIT.[8]

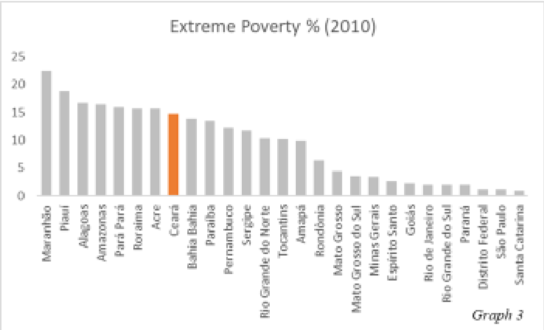
Ceará stands out in both private and public sectors, as mentioned before, a poor State of Brazilian Northeast, which presents low per capita income (*graph 1*), high social inequality level, or IDH-M (*graph 2*), and high rate of people in extreme poverty (*graph 3*), comparing to other States. On the other hand, Ceará presents great results of educational indicators (*map 1*), including:



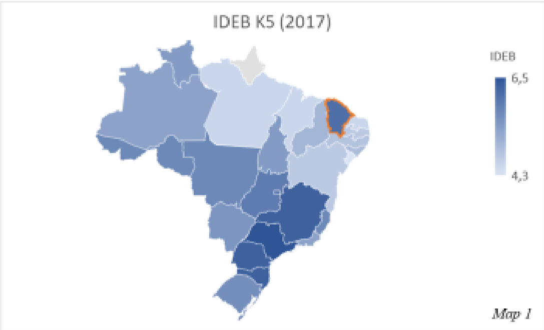
Graph 1



Graph 2



Graph 3



Map 1

- 82 of 100 of the best Brazilian public schools;[9]
- 6 of the 10 best cities on 2017's IDEB (Basic Education Development Index);[10]
- Sobral case, the city with the best Brazilian public education;[11]
- Granja case (a city in Ceará), which has 9 of the 10 best Brazilian schools in reading;[12]
- representatives sent annually to international Olympiads, obtaining good results;[13]
- in the last ten years, the Capital of Ceará, Fortaleza, was eight times the city that approved more students in ITA, considered to be the most competitive entrance examination (higher education), in Brazil.[14]

In the face of this interesting scenario, this study focuses on the State of Ceará, which endures difficulties related to economic conditions, infrastructure, nutrition, and transport, but presents good educational practices, as well as good indicators. Besides that, there is the geographical influence of the predominant biome in the State. Ceará is completely situated in the Caatinga, only biome which can be found solely in Brazil, presenting semi-arid climate, vegetation with scarce leaves, and adapted to long periods of drought. A certain Caatinga region is named *agreste* and is characterized by drought and rocky soil. The word *'agreste'*, as well as the word *'sertanejo'*, due to historical facts of the Northeast region and Brazilian literature, are also used to characterize environments of harsh and precarious conditions, being used in this study to explain the situation of most public school students in Ceará. A characteristic belonging to people in this region, described as such because of social stereotypes, is that of resiliency, which reminds of the vegetation in this environment.

"*The sertanejo is, above all, a strong man.*" (Cunha, 1902)

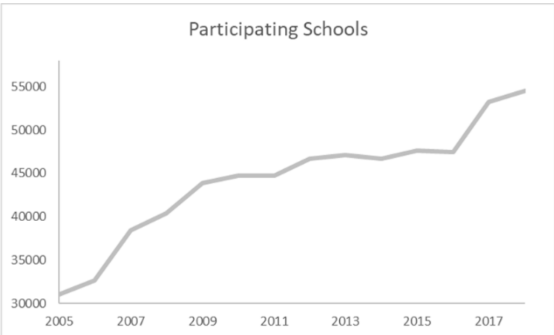
It is important to highlight that Ceará has improved education indicators in the last 15 years, suggesting that these results come from the latest government policies dedicated to Education. In 2007, IDEB's first year, Ceará took the 15th place of all 27 Federal Units in Brazil, obtaining a score of 3.8. In 2017, it reached 5th place, with score 6.1, above the average of OECD countries (an equivalent to 6.0 IDEB mean). At this time, Ceará was the state that most progressed on IDEB (K5 students).

3. OBMEP and Ceará

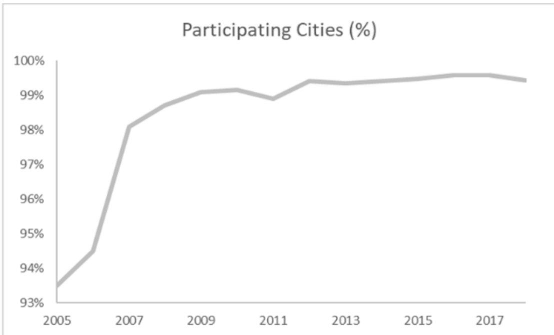
Considering the Brazilian reality, it is expected that few students believe in the possibility of being awarded in the science olympiads or comprehend the importance of such an award. Among those who believe, possibly a few of them have access to information or proper support to follow the necessary journey. They do not know how much effort they have to dedicate or if it will be worth the cost. When students of a certain environment obtain awards and, consequently, become role models, they add information, making the rules of the game clear, and reducing the transaction cost. Furthermore, they become examples that their peers might be willing to follow.

Nevertheless, medal winners are punctual, being necessary for the creation of incentive policies that allow the continuation of these results, some national and local factors can support this spillover. For example, OBMEP (Brazilian Mathematics Olympiad of Public Schools), the most important science olympiad in Brazil, which happens in a high regularity pattern concerning the participants and awarded number, making the rules of the game reliable. Since its beginning, in 2005, OBMEP has grown considerably when it comes to participant schools (*graph 4*), and percentage of Brazilian cities with participant students, more than 99% in Brazil (*graph 5*).

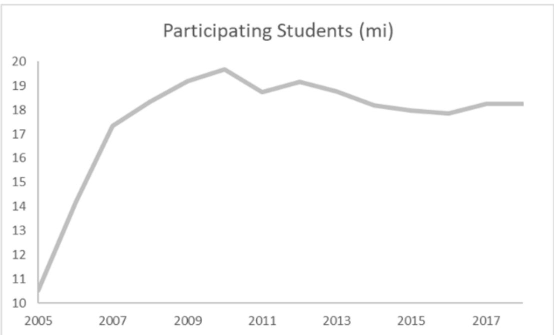
Moreover, the gross quantity of participant students in the first phase of the Olympiad is about 18 million annually (*graph 6*), the equivalent of the population in Portugal and Switzerland combined. In the end, the quantity of awarded students is determined by a fixed rule, which has progressively increased as the competition got famous (*graph 7*).



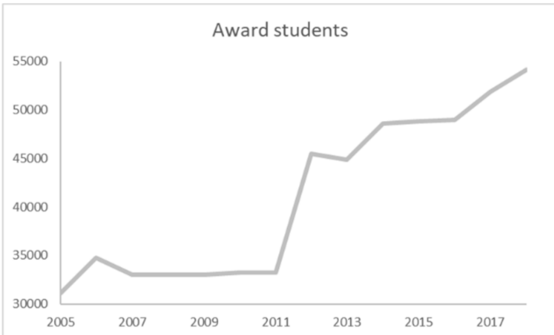
Graph 4



Graph 5



Graph 6



Graph 7

Furthermore, it is extremely important to guarantee that good pedagogic and managerial practices which allow schools to stand out in OBMEP are able to spillover towards other environments. Ceará favors this practice due to its educational system of subdivisions. In the present, the 184 municipalities in Ceará are divided into 21 CREDES (Regional Education Development Coordinators), following their geographical locations. Each region has a department that reports directly to the State Education Bureau.

Municipalities must meet some goals within their CREDEs, which should be aligned to national and regional education indicators, guaranteeing that neighboring municipalities meet them as well. These goals have an influence on extra funds for the region. Thus, there is a great incentive for the exchange of good management practices. It is also frequent, due to the size of most cities in Ceará, the relocation of teachers, coordinators, principals, and secretaries to cities within the same region. Simultaneously, States offer constant training for the CREDE’s employees, who are responsible for the instruction of municipality employees on these practices, standardizing the information.

Furthermore, Ceará counts with its own evaluation of public-school performance, which happens annually through census, named SPAECE (Permanent Evaluation System for Basic Education in Ceará). This indicator allows Ceará to have a closer monitoring of each school and city, making it easier for the identification of problems and successful cases.

4. Data

The data used in this work comes from three different sources:

SAEB - National Basic Education Assessment System: the evaluation started in the 1990s and occurs every odd year. It is the first Brazilian initiative to better understand national education. It is applied for students from K5 and K9, grades in which a student changes segment. The test, called Prova Brasil, comprises Mathematics and Portuguese, being applied as a census, only for schools with more than 20 students. It is used to create

IDEB (Basic Education Development Index), which is aligned with PISA (Programme for International Student Assessment).

Censo Escolar - School Census: created in 2007 and applied annually. It receives and organizes the information about students, teachers, managers of all Brazilian schools, except Higher Education, involving students, managers, staff, and teachers.

OBMEP - Brazilian Mathematics Olympiad of Public Schools: created in 2005, it is the biggest Science Olympiad in the world, with almost 20 million students every year, 99.7% of Brazilian schools in 2019. It is divided into three levels, N1 (K6 and K7), N2 (K8 and K9), and N3 (from K10 to K12). About 54,100 students are awarded every year (medals and honorable mentions), with more than 7,200 becoming medalists (only medals).

Because of the focus on the *agreste* environment, this study will consider a specific State in Brazil, namely Ceará. Located in the Northwest, Ceará holds IDEB 6.1 of K5 in 2017, above the target 6.0, the equivalent of the OECD average in PISA. Its IDEB in K9, also in 2017, is 4.9, below the target, but above Brazilian average 4.4. Ceará is known as a niche for good practice in education. Considering K5's IDEB, Ceará has 82 of the 100 best public schools in Brazil, and 54 of the best 100 in K9. Besides that, Ceará has 6 of the best 10 cities in Brazil, also considering K5.

Besides that, a specific school in Ceará stands out due to its exceptional and constant performance, the CMF. It holds 151 OBMEP gold medals out of 241 won by schools in Ceará between 2005 and 2018. The second best school in the number of medals accounts for only 8 gold awards in the same period. There are only 13 military schools in Brazil, all being institutions of high performance, with pre-selection tests, although being public. The CMF has stood out as one of the best in this group. Due to this discrepancy, this school was not included in the analysis, for it cannot be considered as an *agreste* type.

The final base includes information about 1,882 different public schools, between 2009 and 2017, odd years only. It is not possible to follow specific students over the years because of data secrecy. Thus, to study the impact on peers of receiving a prize on OBMEP the dependent variable is the score of Mathematics of the participant schools in OBMEP, leaving three possibilities: SAEB for K5, SAEB for K9, and ENEM for K12.

K5 students do not participate in OBMEP, so they cannot be considered as an option. On the other hand, the ENEM (K12) presents a logistic problem regarding data. Students need to inform their school in their registration, an optional item that is far from complete fulfillment by the majority. Hence, the focus will be on K9 because of data restriction.

The independent variables can be divided into four: each variable refers to the number of awards won by a school in the last two years in their respective category: *gold*, *silver*, *bronze,* and *honorable mention*. Moreover, it is built a variable named *other*, which is the sum of *silver*, *bronze,* and *honorable mention*. It is worth mentioning that the quantity of medals considers K6 to K9 students, for there is the intention to evaluate the impact of medal winners on the school environment.

Finally, there are various social and economic controls taken from the SAEB and School Census basis, which happen annually (table 7, Appendix 1). There are also the cluster variables, adding robustness to the model, which are CREDE (aforementioned State subdivision) and school dependency (Federal, State, and municipal govern).

Regarding the impact of awards in students' lives, the honorable mention is limited to a certificate and the possibility of participation in PIC-Jr in the year that follows the winning of the award. The program takes 12 months, which can be extended if students win a medal again, and comprises monthly classes at scientific centers with high quality in Mathematics. Moreover, students receive a monthly scholarship of R$100.00, which is significant, considering the early age of the students and average income in Ceará, R$1981.60 in 2018. However, not all honorable mentions guarantee a place in PIC-Jr, as well as the scholarship, for there is a pre-selection process.

The bronze and silver awards are quite similar: guaranteed places in PIC-Jr and a monthly scholarship of R$100.00. Nevertheless, the medals for these two places have great recognition, and there is a regional ceremony for the award, besides being rare when compared to honorable mentions. Students' appreciation of these medals is one level higher than that of honorable mentions, considering the perception of students, teachers, and families.

Table 1 reports the mean and standard deviation for some variables for the full data over the years.

Table 1: Descriptive statistics

	2009 N = 1353	2011 N = 1349	2013 N = 1259	2015 N = 1066	2017 N = 1520
Outputs					
Math score	229.18 (16.07)	237.14 (18.24)	241.55 (19.54)	254.00 (20.15)	259.57 (26.68)
Awards in the last two years					
Gold	0.00074 (0.027)	0.00074 (0.027)	0.00238 (0.049)	0.00094 (0.031)	0.00526 (0.081)
Silver	0.011 (0.17)	0.008 (0.11)	0.006 (0.13)	0.009 (0.11)	0.017 (0.14)
Bronze	0.019 (0.29)	0.016 (0.18)	0.016 (0.13)	0.057 (0.26)	0.069 (0.40)
Honorable Mention	0.312 (1.19)	0.329 (1.12)	0.513 (1.62)	0.711 (1.79)	0.882 (1.62)
Baseline Variables					
% Male students	0.509 (0.041)	0.516 (0.037)	0.518 (0.037)	0.519 (0.036)	0.522 (0.036)
% White students	0.091 (0.091)	0.114 (0.101)	0.127 (0.097)	0.141 (0.099)	0.151 (0.105)
% Pardo students	0.367 (0.219)	0.492 (0.242)	0.559 (0.224)	0.604 (0.207)	0.646 (0.200)
% Teachers with Tertiary Education	0.799 (0.197)	0.861 (0.156)	0.838 (0.164)	0.698 (0.211)	0.675 (0.205)
% Students who failed at least once	0.404 (0.139)	0.398 (0.139)	0.475 (0.146)	0.401 (0.142)	0.356 (0.123)

Notes: Author's elaboration. Table reports means and standard deviation based on data from OBMEP, Scholar Census, and SAEB.

Last but not least, the gold is the higher award and it is recognized in a national ceremony organized by OBMEP. The 500 students awarded gold in Brazil, from K6 to K12, travel to Rio de Janeiro and receive the award from famous public personalities, such as the Brazilian president and Minister of Education. Traveling and staying in good hotels in Rio de Janeiro represent something beyond most students' reality. Moreover, the presence of lots of young people and teachers that also stood out in the Olympiad creates an experience that differentiates the impact in an award winner's life, but moreover, it creates an environment with more information and more motivation, which may overflow such effects and increase the average performance of the school. It is the spillover generated by a role model that this work wants to test.

5. Empirical Strategy

> *"Statistical models that combine cross section and time series data offer analysis and interpretation advantages over separate cross section or time series data analysis*". Mátyás & Severstre (1996).

The data structure, in which it is possible to observe the same schools (1,882 in total, 688 of them presenting information in all periods), over 5 periods (2009 to 2017, odd years), with lots of information of the program (OBMEP awards), social and economic information of the schools (skin color proportion, parents' education, the financial situation of the family, teachers' qualification, etc), and cluster information of schools (regional subdivision in CREDEs), allows the use of panel model.

However, the timeline is an important factor to understand the impact of an award on the average school math score, i.e., on the peers of the awarded. Assuming as the base year 2015, SAEB takes place in October (math score), while OBMEP takes place in September, but its result is only announced in December. In other words, the 2015 OBMEP does not affect the 2015 SAEB results. In this example, the next SAEB will be in 2017. Therefore, the 2015 and 2016 awards in OBMEP will be the only ones that will affect 2017 SAEB results.

Proceeding, a panel presents the form:

$$\text{(I)} \qquad X_{it},\ i = 1, \dots, N,\ t = 1, \dots T,$$

In the case presented, i represents the individual, the schools, and t the time period, odd years between 2009 and 2017. The panel data model can be described as follows:

(II) $\quad Y_{it} = \alpha + \beta' X_{it} + \delta' Z_{it-2} + c_i + \varepsilon_{it}$, being:

Y_{it} the dependent variable, Mathematics Score in Prova Brasil;

X_{it} the vector of control variables;

Z_{it-2} the vector of explanatory variables, awards in OBMEP in the past two years;

α is the intercept;

c_i the individual-specific effect;

ε_{it} the *idiosyncratic* error term.

The model used will be Fixed Effects or Random Effects, being the choice based on Hausman test, i.e. the correlation of the individual-specific effect, c_i, with the explanatory variables.

Anyway, it is important to mention the basic assumptions of the panel model:

1. Homoscedastic errors, non-correlated, and independent: $\varepsilon_{it} \sim N(0; \sigma_\varepsilon^2)$;
2. Random sample in cross-sectional dimension;
3. Model linearity.

For robustness, this study will also use the Difference in Differences model to evaluate the impact of awards between consecutive periods. The methodology of this model is presented in Appendix 2. The analysis is useful to reinforce the results, and for comparison with the results found in Moreira (2017) and Biondiat (2012), both concerning OBMEP.

6. Results

The first step in the analysis consisted of estimating the standard model twice, none with the use of cluster variables, the first one assuming fixed effects, and the second, variable effects. For both of the models, the results of the estimation were saved, and Hausman test executed, following this hypothesis:

H_0: *both models are consistent, but the random effect is the only efficient*

H_1: *difference in coefficients not systematic – the fixed effect is the only consistent model*

For the initial model and its modifications, which will be done subsequently, Hausman test strongly indicates that the null hypothesis is rejected, leading to the use of the fixed effect model.

To consider the possible heteroscedasticity and serial correlation it was used cluster robust covariance errors in the estimation. For this, it is worth remembering that the analyzed schools are in the same State, all being public, characterizing as *agreste* schools, and can be well categorized in clusters, because of the CREDE system.

Hence, it follows the last part of the analysis, the attempt to verify separately the four main groups: *gold*, *silver*, *bronze,* and *honorable mention*. So, each coefficient indicates the impact of its respective award (*table 2*).

Table 2: Panel FE Estimation

Math score	Coef.	Std. Err.	P > | t |
Gold	7.03	5.29	0.18
Silver	3.03	2.39	0.20
Bronze	1.88	1.18	0.11
Honorable Mention	2.07	0.29	0.00
Number of students	0.00	0.00	0.51
% Male students	3.48	9.96	0.723
% White students	21.42	5.68	0.00
% Pardo students	13.01	1.91	0.00
% Students who use public transport	15.31	2.76	0.00
% Students whose parents own a car	48.71	2.36	0.00
% Teachers with Tertiary Education	-12.45	1.74	0.00
% Parents with Tertiary Education	29.67	6.81	0.00
% Students who failed at least once	-41.42	2.22	0.00
Constant	239.52	5.67	0.00

Notes: Author's elaboration. Table reports Fixed-effects (within) regression

Therefore, there is evidence of the positive impact of an award in general. However, there is no guarantee of the impact of *silver* or *bronze* due to the p-value. On the other hand, observing the experience of an awarded student and its impact on the school environment in which she is inserted, there is there are no big differences between *silver*, *bronze*, and *honorable mention*.

Hence, two groups will be reversed: *gold*, the number of *gold* awards in the last two years of a school, and other, the number of awards different from *gold* in the last two years, i.e. the sum of *silver*, *bronze* and *honorable mention* (*table 3*).

Table 3: Panel FE Estimation

Math score	Coef.	Std. Err.	P > | t |
Gold	6.72	3.01	0.03
Other	2.09	0.43	0.00

Notes: Author's elaboration. Table reports Fixed-effects (within) regression

Finally, there is evidence of the positive impact of an award in general. Besides that, the *gold* medal differs from the other awards in terms of impact. Its coefficient is quite high, differently from the previous cases.

Considering an analysis of Difference in Differences (DiD), the loss of information due to a drop in the number of individuals and periods leads to the conclusion that a separate analysis between distinct awards is not viable. Therefore, it will be considered only the group d_prem, an award dummy which indicates whether schools have got, 1 or 0, any award in the last two years. The process is done between 2015 and 2017, the two most recent years of Prova Brasil. The results are shown in *table 3*.

Therefore, with 99% confidence, there is evidence that OBMEP awards increased the Mathematics score of Ceará public schools in Prova Brasil by 5.17 points, between 2015 and 2017, on average and ceteris paribus.

Table 4: DiD Regression

Before	Coef.	P > | t |
Control	256.92	
Treated	262.55	
Diff (T-C)	5.63	0.012
After	Coef.	P > | t |
Control	258.20	
Treated	269.00	
Diff (T-C)	10.80	0.001
DiD	5.17	0.003

Notes: Author's elaboration. Table reports DiD regression

Lastly, with 99% confidence, one only award: *silver, bronze,* or *honorable mention*, has an impact, on average, and ceteris paribus, of 2.09 on the Mathematics score of a school in the next Prova Brasil. Moreover, with 97% confidence, a *gold* medal has the impact, on average and ceteris paribus, of 6.72 on the Mathematics score of a school in the next Prova Brasil. The DiD model between 2015 and 2017 reinforces these results.

7. Conclusions

The academic literature argues that competitions improve not only the results of those students that receive awards but also of classmates. Having a closer look at the context of competitions in the Brazilian public system, with OBMEP as the greatest example, two studies reflect that literature.

Moreira (2017) uses Discontinuity Regression between 2009 and 2012, observing awards in general, without stratifying them as medal types, to demonstrate that awards increase the performance of both groups, award winners, and their classmates.

On the other hand, there are the results found in Biondi et al (2012), which use propensity score with a standard model of regression and focus on the data provided by the Prova Brasil of 2007. Moreover, it is developed a cost-benefit analysis using the elasticity performance/income found in Binelliand Menezes-Filho (2008). In this case, the aim is to analyze the effect in the performance for the schools that participated in OBMEP, as well as understand if participating several times has a cumulative effect.

> "We showed that the OBMEP has a positive and statistically significant effect on the average Math scores of the 9th-graders of schools on the Prova Brasil (2007). This impact rises as the number of times the school participates in the program increases, and is greater in the higher student score percentiles, although all percentiles benefit from the Olympics." Binelliand Menezes-Filho (2008)

In this work is demonstrated with the use of the panel model with fixed effects and data from 2009 to 2017 that there is statistical evidence of a positive impact of gold and other awards. Each common award (*silver*, *bronze,* and *honorable mention*) has an impact of 2.09 on the Mathematics score in the next Prova Brasil, while each *gold* award has an impact of 6.72 on the Mathematics score in the next Prova Brasil.

These impacts are beyond those of the participation in OBMEP itself, i.e. effects beyond that already found in Binelliand Menezes-Filho (2008). It is possible to establish this extrapolation considering the small number of awards per year per school, compared to the total number of students. It suggests that generating a local example, a role model, brings effects not only to the awarded student but also for your peers, implying the relevance of the spillover effect.

Some possible future step of this study is to observe the result for the other 8 states in northeastern Brazil and the northeast as a group, trying to understand what factors may allow an award to have more or less impact.

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Appendix 1 – Data Dictionary

Table 4: Data Dictionary

Variable	Database	Description	Observation
inep	Censo / SAEB / OBMEP	school ID	number, 8 digits
male	Censo	school's male student	percentage
white	Censo	school's students who consider themselves white	percentage
pardo	Censo	school's students who consider themselves brown or black	percentage
transp	Censo	school's students who use public transport	percentage
qtd	Censo	schools's total amount of students	number
year	Censo / SAEB / OBMEP	between 2009 and 2017, only odd	number, 4 digits
teacher_he	Censo	school's teachers who have completed college	percentage
city	Censo / SAEB	city ID	number, 7 digits
dependenc	Censo / SAEB	1 - Federal / 2 - State / 3 - Municipal	number, 1 digit
urbana	Censo / SAEB	urban school	dummy
math	SAEB	school's average grade in Math	number between 0 and 500
car	SAEB	school's students parents have at least a car	percentage
parents_he	SAEB	school's students who have at least a parent with higher education	percentage
failed	SAEB	school's students who have failed at least once	percentage
gold	OBMEP	school's amount of gold medals received in the last two years between K6 and K9	number
silver	OBMEP	school's amount of silver medals received in the last two years between K6 and K9	number
bronze	OBMEP	schools' amount of bronze medals received in the last two years between K6 and K9	number
honorable mention	OBMEP	schools' amount of honorable awards received in the last two years between K6 and K9	number
other	OBMEP	sum of gold, silver and bronze medals in the last two years between K6 and K9	número
crede	Own source	school's state microregion	number between 1 and 21

Notes: Author's elaboration. Data dictionary

Appendix 2 – Differences in Differences

The quasi-experimental method of Differences in Differences requires data from a treatment group and a control group for two or more different periods. Its main supposition is the parallel trend assumption, in addition to the usual suppositions of the OLS model. A Parallel Trend Assumption demands that, in the absence of treatment, the difference between the treatment group and the control group be constant throughout the periods worked. Although there is not a statistic test to validate the hypothesis, a graphic and visual inspection is valid when there are data throughout different times. Furthermore, the shorter the time span, it is more probable that the supposition is valid.

Being i the variable 'individual' and t 'time', consider the model:

$$\text{(III)} \quad y_{it} = \gamma_{s(i)} + \lambda_t + \delta I + \varepsilon_{it}$$

In which y_{it} is the independent variable, s(i) the group to which the individual belongs (treatment or control), and I (…) a dummy which takes value 1 when the event (…) happens and 0 otherwise.

On the opposite side, $\gamma_{s(i)}$ represents the intercept to s, which changes between groups, and λ_t is the time tendency, which is the same for both groups. δ represents the effect of the treatment and ε_{it} is the residue.

Considering n_s the number of individuals in group s, so:

$$\text{(IV)} \quad \bar{y}_{st} = \frac{1}{n_s}\sum_{i=1}^{n} y_{it}\, I(s(i) = s),$$

$$\text{(V)} \quad \bar{\gamma}_{st} = \frac{1}{n_s}\sum_{i=1}^{n} \gamma_{it}\, I(s(i) = s) = \gamma_s,$$

$$\text{(VI)} \quad \bar{\lambda}_{st} = \frac{1}{n_s}\sum_{i=1}^{n} \lambda_{it}\, I(s(i) = s) = \lambda_s,$$

$$\text{(VII)} \quad D_{st} = \frac{1}{n_s}\sum_{i=1}^{n} I(s(i) = treatment, t\ in\ after\ period) = \lambda_s,$$

$$\text{(VIII)} \quad \bar{\varepsilon}_{st} = \frac{1}{n_s} \sum_{i=1}^{n} \varepsilon_{it} \, I(s(i) = s),$$

And taking, by simplification, that *s* = 1.2 and *t* = 1.2. Therefore, it is possible to prove that, without loss of generalization:

$$\text{(IX)} \quad \delta = (\bar{y}_{11} - \bar{y}_{12}) - (\bar{y}_{11} - \bar{y}_{12})$$

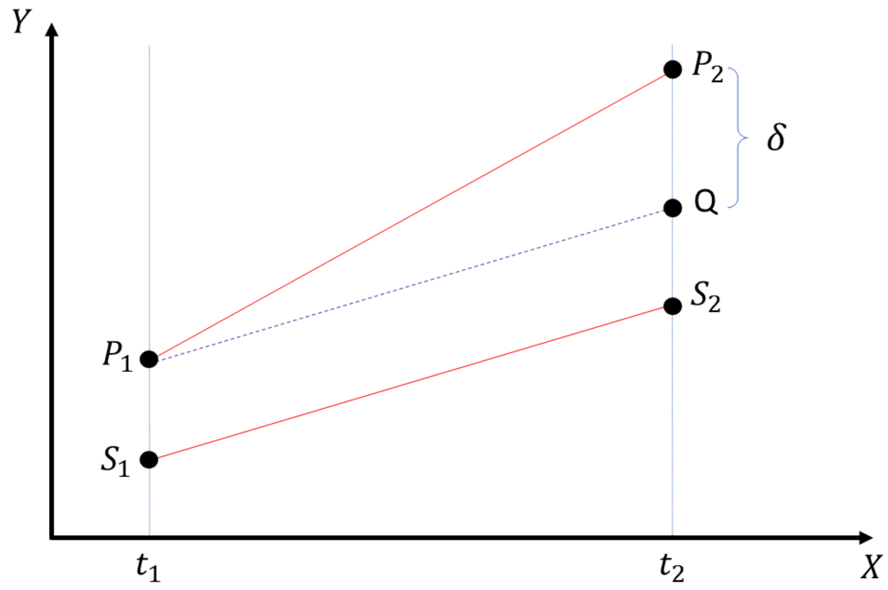

Figure 1